V.—*On the Geological Distribution of the Rhabdophora.*

By CHARLES LAPWORTH, F.G.S. &c.

Part III. RESULTS.

[Continued from vol. v. p. 369.]

TABLE X. Showing the Vertical Range of the Genera and Species of the British Rhabdophora.

	CAMBRIAN.		ORDOVICIAN.								SILURIAN.								
			Lower.				Upper.		Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Family I. MONOGRAPTIDÆ.																	
Group i. (type *M. Nilssoni*, Barr.).																	
Monograptus tenuis, *Portl.*	..	..	..	..	..	..	..	..	*	*	*						
—— attenuatus, *Hopk.*	..	..	..	..	..	..	..	..	*	*	*	*					
—— gregarius, *Lapw.*	..	..	..	..	..	..	..	..	..	*	*						
—— argutus, *Lapw.*	..	..	..	..	..	..	..	..	..	*	*						
—— concinnus, *Lapw.*	..	..	..	..	..	..	..	..	..	..	*	*					
—— intermedius, *Carr.*	..	..	..	..	..	..	..	..	..	..	*						
—— bohemicus, *Barr.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*	*	
—— Nilssoni, *Barr.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*	
—— scanicus, *Tullberg*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*	
Group ii. (type *M. Hisingeri*, Carr.).																	
Monograptus leptotheca, *Lapw.*	..	..	..	..	..	..	..	..	..	*							
—— cyphus, *Lapw.*	..	..	..	..	..	..	..	..	..	*	*						
—— crenularis, *Lapw.*	..	..	..	..	..	..	..	..	..	..	*						
—— argenteus, *Nich.*	..	..	..	..	..	..	..	..	..	*	*						
—— Hisingeri, *Carr.*																	
—— ——, var. jaculum, *Lapw.*	..	..	..	..	..	..	..	..	..	..	*	*					
—— ——, var. nudus, *Lapw.*	..	..	..	..	..	..	..	..	..	..	..	*	*				
—— ——, var. rigidus, *Tullb.*	..	..	..	..	..	..	..	..	..	..	..	..	*	*	*		
—— nuntius, *Barr.*	..	..	..	..	..	..	..	..	..	..	..	..	..	?	?		
—— vomerinus, *Nich.*	..	..	..	..	..	..	..	..	..	..	..	..	*	*	*		

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.								SILURIAN.								
			Lower.			Upper.			Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Group iii. (type *M. colonus*, auct.).																	
Monograptus galaensis, *Lapw.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	V.			
—— testis, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*		
—— dubius, *Suess*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	
—— Halli, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	?	?	
—— colonus *auct.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	
—— leintwardinensis, *Hopk.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	
—— Rœmeri, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	
—— Salweyi, *Hopk.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	
—— chimæra, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	?	?	
Group iv. (type *M. priodon*, Bronn).																	
Monograptus crassus, *Lapw.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*					
—— clintonensis, *Hall*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	?	?			
—— priodon, *Bronn*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	*			
—— ——, ? var. Flemingii, *Salt.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*		
—— ——, ? var. ludensis, *Murch.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	
—— riccartonensis, *Lapw.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	*		
Group v. (type *M. lobiferus*, M'Coy).																	
Monograptus lobiferus, *M'Coy*	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*						
—— Clingani, *Carr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*						
—— Becki, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*					
—— exiguus, *Nich.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*					
—— Salteri, *Lapw.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*				
—— crispus, *Lapw.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*				
—— proteus, *Barr.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	?				
—— Barrandei, *Suess*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*			
Group vi. (type *M. Sedgwicki*, Portl.).																	
Monograptus triangulatus, *Harkn.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	*							
—— fimbriatus, *Nich.*	. .	. .	. .	. .	. .	. .	. .	. .	. .	*	*	*					

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.						SILURIAN.								
			Lower.			Upper.			Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Monograptus Sedgwicki, *Portl.*											*	*					
—— spiralis, *Geinitz*											*	*	V.				
—— turriculatus, *Barr.*											*	*					
Cyrtograptus Grayæ, *Lapw.*													*				
—— Murchisoni, *Carr.*														*			
—— Carruthersi, *Lapw.*														*			
—— hamatus, *Baily*															?		
—— Linnarssoni, *Lapw.*															*		
Family II. LEPTOGRAPTIDÆ.																	
Group *a*.																	
Leptograptus capillaris, *Carr.*							*										
—— flaccidus, *Hall*						*	*										
Amphigraptus divergens, *Hall*							*										
—— radiatus, *Lapw.*							*										
Pleurograptus linearis, *Carr.*							*										
Group *b*.																	
Cœnograptus gracilis, *Hall*						*											
—— surcularis, *Hall*						*											
—— pertenuis, *Lapw.*						*											
—— explanatus, *Lapw.*						*											
Azygograptus cœlebs, *Lapw.*				*													
—— Lapworthi, *Nich.*			*														
Family III. DICRANOGRAPTIDÆ.																	
Dicellograptus anceps, *Nich.*								*									
—— caduceus, *Lapw.*							*										
—— complanatus, *Lapw.*								*									
—— divaricatus, *Hall*						*											
—— elegans, *Carr.*							*	*									
—— Forchhammeri, *Geinitz*							*										
—— furcatus, *Hall*						*											
—— intortus, *Lapw.*						*											

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.						SILURIAN.								
			Lower.				Upper.		Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Dicellograptus moffatensis, *Carr.*							*										
—— Morrisi, *Hopk.*							*										
—— patulosus, *Lapw.*						*											
—— sextans, *Hall*						*											
—— pumilus, *Lapw.*							*										
Dicranograptus Clingani, *Carr.*							*										
—— formosus, *Hopk.*						*											
—— Nicholsoni, *Hopk.*						*	*										
—— ramosus, *Hall*						*	*										
—— ziczac, *Lapw.*						*											
Family IV. DICHOGRAPTIDÆ.																	
i. (type *D. Murchisoni*, Beck).																	
Didymograptus bifidus, *Hall*				*													
—— indentus, *Hall*			*	*													
—— ——, var. nanus, *Lapw.*				*	*												
—— minutus, *Törnquist*				*													
—— Murchisoni, *Beck*					*												
—— ——, var. furcillatus, *Lapw.*					*												
—— ——, var. geminus, *His.*					*												
ii. (type *D. v-fractus*, Salter).																	
Didymograptus balticus, *Tullberg*			*														
—— vacillans, *Tullberg*		*															
—— v-fractus, *Salter*			*														
—— Pantonii, *M'Coy*			*														
iii. (type *D. patulus*, Hall).																	
Didymograptus constrictus, *Hall*			*	*													
—— extensus, *Hall*			*	*													
—— ——, var. euodus, *Lapw.*					*												
—— nitidus, *Hall*			*														
—— patulus, *Hall*			*	*													
—— similis, *Hall*			*														
—— superstes, *Lapw.*						*											
—— suecicus, *Tullberg*				*													

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.						SILURIAN.								
			Lower.				Upper.		Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
iv. (type *D. fasciculatus*, Nich.).																	
Didymograptus fasciculatus, *Nich.*				*													
v. (type *D. pennatulus*, *Hall*).																	
Didymograptus gibberulus, *Nich.*			*														
—— sparsus, *Hopk.*			*														
—— pennatulus, *Hall*			*														
vi. (type *D. affinis*, Nich.).																	
Didymograptus affinis, *Nich.*			*	*													
—— filiformis, *Tullb.*			*														
—— Nicholsoni, *Lapw.*			*	*													
—— pusillus, *Tullb.*			*														
—— serratulus, *Hall*					*												
—— strictulus, *Linnrs.*			*														
Tetragraptus approximatus, *Nich.*			*														
—— bryonoides, *Hall*			*														
—— Bigsbyi, *Hall*			*														
—— denticulatus, *Hall*			*														
—— fruticosus, *Hall*			*														
—— Halli, *Hopk.*			*														
—— Headi, *Hall*			*														
—— (?) Hicksi, *Hopk.*			*	?													
—— quadribrachiatus, *Hall*			*														
Dichograptus Sedgwicki, *Salt.*			*														
—— octobrachiatus, *Hall*			*														
—— (?) tenellus, *Linnrs.*	*																
Loganograptus Logani, *Hall*			*														
Clonograptus rigidus, *Hall*	?		*														
—— flexilis, *Hall*			*														
Schizograptus reticulatus, *Nich.*			*														
Temnograptus multiplex, *Nich.*			*														
Goniograptus Thureaui, *M'Coy.*			*														
Bryograptus Callavei, *Lapw.*	*																
—— Kjerulfi, *Lapw.*	*																
Clematograptus implicatus, *Hopk.*			*														
—— multibrachiatus, *Hall*				?													
Trichograptus fragilis, *Nich.*				*													

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.						SILURIAN.								
			Lower.				Upper.		Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Family V. PHYLLOGRAPTIDÆ.																	
Phyllograptus angustifolius, *Hall.*			*	*													
—— Anna, *Hall*			*														
—— densus, *Törnq.*				*													
—— typus, *Hall*			*														
—— stella, *Hopk.*			*														
Family VI. DIPLOGRAPTIDÆ.																	
Diplograptus inutilis, *Hall*			*														
—— dentatus, *Brongn.*				*	*	*											
—— angustifolius, *Hall*						*											
—— amplexicaulis, *Hall*						*											
—— euglyphus, *Lapw.*						*											
—— rugosus, *Emmons*					*	*											
—— Whitfieldii, *Hall*						*											
—— foliaceus, *Murch.*					*	*	*										
—— truncatus, *Lapw.*							*	*									
—— hudsonicus, *Nich.*							*										
—— quadrimucronatus, *Hall*							*										
—— pristis, *His.*								*									
—— socialis, *Lapw.*								*									
—— aculeatus, *Lapw.*							*	*									
—— vesiculosus, *Nich.*									*	*							
—— acuminatus, *Nich.*									*								
—— modestus, *Lapw.*										*	*						
—— insectiformis, *Nich.*										*							
—— tamariscus, *Nich.*										*	*						
—— physophora, *Nich.*										*							
—— Hughesi, *Nich.*											*						
—— sinuatus, *Nich.*											*						
—— folium, *His.*										*	*						
—— palmeus, *Barr.*											*	*					
Dimorphograptus elongatus, *Lapw.*									*								
—— Swanstoni, *Lapw.*										*							
Cephalograptus cometa, *Gein.*											*						
Cryptograptus tricornis, *Carr.*			?			*	*										
—— Schæferi, *Lapw.*						*											

TABLE X. (*continued*).

	CAMBRIAN.		ORDOVICIAN.						SILURIAN.								
			Lower.			Upper.			Lower.					Middle.			
			Arenig.		Llandeilo-Bala.		Caradoc-Bala.		Llandovery Rocks.			Tarannon.		Wenlock.		Ludlow.	
	Olenus-Beds.	*Dictyonema*-Beds.	Lower Zones.	Upper Zones.	*Didymograptus*-Beds.	Glenkiln Beds.	Lower Hartfell.	Upper Hartfell.	Lower Birkhill.	Middle Birkhill.	Upper Birkhill.	Lower Gala.	Upper Gala.	Lower Zones.	Upper Zones.	Lower Ludlow.	Upper Ludlow.
Cryptograptus antennarius, *Hall*			*														
—— Hopkinsoni, *Nich.*			*	*													
Climacograptus cælatus, *Lapw.*				*													
—— Scharenbergi, *Lapw.*					*	*	*										
—— confertus, *Lapw.*				*	*	*											
—— caudatus, *Lapw.*							*										
—— bicornis, *Hall*						*	*	*									
—— tubuliferus, *Lapw.*							*	*									
—— normalis, *Lapw.*									*	*	*	*					
—— rectangularis, *M‘Coy*										*							
—— innotatus, *Nich.*										*							
Family VII. LASIOGRAPTIDÆ.																	
Lasiograptus Harknessi, *Nich.*							*										
—— costatus, *Lapw.*						*											
—— retusus, *Lapw.*						*											
—— margaritatus, *Lapw.*							*	*									
Hallograptus bimucronatus, *Nich.*						*											
—— mucronatus, *Hall*						*											
Glossograptus Hincksi, *Hopk.*						*	*										
—— armatus, *Nich.*				*													
—— ciliatus, *Emmons*				*		?											
Retiograptus tentaculatus, *Hall*			*														
Family VIII. RETIOLITIDÆ.																	
(Retiograptus) eucharis, *Hall*							*										
Clathrograptus cuneiformis, *Lapw.*						*											
—— Geinitzianus, *Hall*						*											
Gymnograptus Linnarssoni, *Tullb.*					*												
Trigonograptus lanceolatus, *Nich.*				*													
—— ensiformis, *Hall*			*														
—— truncatus, *Lapw.*			*														
Retiolites Geinitzianus, *Barr.*													*	*			
—— fibratus, *Lapw.*							*										
—— perlatus, *Nich.*										*	*						
—— ——, var. ? Daironi, *Lapw.*											*						
—— obesus, *Lapw.*												*	*				

PALÆONTOLOGICAL (Table X.).—We now enter upon the zoological or palæontological department of our subject. The Table given above, which has been drawn up from a careful examination and comparison of the data already brought forward, summarizes the results of our present knowledge with respect to the vertical range of the known families, genera, and species of Rhabdophora. It will be advisable to review these results in order, for each family and species in its turn, that the provisional conclusions we advocate may be contrasted by the student with the speculations of former investigators and with the results destined to be developed by future discovery.

Family i. **Monograptidæ.**

Contrary to the opinions of the earlier palæontologists, it is now clearly apparent that the important family of the Monograptidæ is strictly confined to Murchison's Upper Silurian system. With the exception of the abnormal genus *Azygograptus* (Nich. & Lapw.) no unilateral genus of Graptolite has hitherto been detected in strata of older date than the Lower Llandovery. As we have already shown, the numerous specimens of *Graptolithus* (*Monograptus*) *sagittarius*, His., *M. tenuis*, Portlk., and *M. Nilssoni*, Barr., noted by Hall, Salter, Baily, and others from Arenig, Bala, and Llandeilo strata were merely fragments of compound species. Where these palæontologists have given figures of the so-called simple forms, a glance at the illustrative drawings is generally sufficient to satisfy the graptolithologist that they are fractions of compound forms. In other cases, the known presence of bilateral genera, whose broken branches have a superficial resemblance to the unilateral species, in great abundance in the formations from which these supposed simple forms are derived furnishes us with a very natural explanation of these erroneous identifications. It is not impossible that future research will lead to the detection, in the highest zones of the Bala formation, of the forerunners of the prolific Monograptidæ of the Valentian and Salopian rocks. But, in the actual state of our knowledge, *the mere presence of a single species of the Monograptidæ may at once be set down as conclusive evidence of the* (*Upper*) *Silurian age of its containing beds.*

The range of the entire family appears to be coextensive with that of the Silurian system proper. Its earliest forms struggle into visible existence near the base of the Lower Llandovery, along an horizon which, in the attenuated Graptolite-bearing deposits of Scotland and Scandinavia, is removed but a few feet from the summit of the underlying

Bala formation. The black muddy sea-bed that occupied the region now covered in part by Britain and Scandinavia seems to have been specially favourable for their development; and the increment in species and individuals is so rapid, that by the time we reach the highest zones of the Llandovery, the family has reached its specific maximum, and possibly even begun its decline. The fact that the succeeding Wenlock and Ludlow formations are more arenaceous in their character, and consequently allow of fewer species being preserved to us, deprives this conclusion of some of its weight. Nevertheless their most prolific zones, even when lithologically identical with the teeming beds of the Llandovery, are invariably so poor in the number and variety of their species, that the highest Llandovery subformation may safely be regarded as the metropolis of the family.

1. *Rastrites*, Barrande.—This peculiar genus, so strikingly individualized by its isolated hydrothecæ, had but a very limited existence. It is confined exclusively to the middle zones of the Valentian formation, being absent from its lowest beds, and disappearing before the highest strata are reached. It apparently makes its earliest appearance in the *M. gregarius* zone of the Upper Birkhill, where the well-known species *Rastrites peregrinus*, Barr., occurs in great abundance, associated with its intimate ally, *M. triangulatus*, Harkn. In the succeeding Upper Birkhill zones other species come in, and the genus attains its maximum development. In the overlying Gala Tarannon beds one or two species occur rarely, and in the Lower division only. In the Upper Gala the genus appears to have wholly disappeared.

2. *Monograptus*, Geinitz (*restricted*).—This is the richest and most important of the three genera which compose the family of the Monograptidæ; and its vertical range is so extended that it is coextensive with that of the entire family. The oldest fragments of *Monograptus* detected by myself were found in the lowest (*D. acuminatus*, Nich.) zone of the Lower Birkhill shale of Moffat. It is impossible to refer these interesting fragments to any known species; but there can be no question that they are true Monograptidæ. In no other locality have examples properly referable to the genus *Monograptus* been found so low in the succession.

The genus *Monograptus* possibly culminates along an horizon which is identical with, or but a short distance above, the boundary-line between the Llandovery and the Tarannon. This is far below the line which marks the middle of the vertical range of the genus. The decrease in species as we pass upwards through the Gala and Tarannon formations seems to be very gradual. The recent researches of Dr. Tullberg in the *Cyrtograptus*-schists of Scania[*] make it very doubtful whether there was any marked falling-off in species till far on in the Wenlock period.

In the Lower Ludlow of Wales and Scandinavia individuals are still very numerous in certain localities, but the species were few and of few types. Here our knowledge of the genus suddenly fails us; for although fragments of the genus have been met with far within the limits of the Upper Ludlow beds, no species has yet been identified.

The several subgroups of *Monograptus* differ greatly in their vertical distribution.

Group i. (*Nilssoni group*) has by far the longest range. It claims *M. tenuis*, Portlk., and *M. attenuatus*, Hopk., which are the oldest Monograptidæ yet discovered, as well as *M. scanicus*, Tullberg, and *M. Nilssoni*, Barr., which are the characteristic forms of the Lower Ludlow formation.

Group ii. (*Hisingeri group*) approaches the first group in the great extent of its geological range; but its oldest forms descend no lower than the Middle Birkhill, while it is doubtful if any true members of the group live on into the Lower Ludlow.

Group iii. (*colonus group*) is the last to come into being, as it seems to be the last to die out. Its oldest known form (*M. galaensis*, Lapw.) is found at the very base of the Gala group. According to Mr. Linnarsson the fragmentary form in the Gothland sandstones (Upper Ludlow?) is of this type.

Its species are markedly characteristic of Upper Wenlock and Lower Ludlow beds. Of its nine recognized forms eight belong to these horizons.

Group iv. (*priodon group*) contains many forms which, according to the views of the Scandinavian palæontologists, are of doubtful specific value; and it is impossible, in the present state of our knowledge, to separate its distinct species and varieties with certainty. The group agrees closely in its vertical range with the preceding. Its oldest form appears in the highest Birkhill beds, and its most recent in the Upper Ludlow of Shropshire. It includes the only *Monograptus* yet quoted from American rocks, which are remarkably poor in members of this family.

Group v. (*lobiferus group*). This group is characteristic of the Valentian or Llandovery-Tarannon rocks, no single species apparently surviving into the Wenlock beds. Its forms appear first in the Middle Birkhill beds, and crowd the Upper Birkhill and Gala beds wherever they are Graptolitiferous. In the Upper Gala beds they are as yet unknown.

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[*] Tullberg, Geol. Fören. Förh. 1880, No. 59, Bd. v. No. 3.

Group vi. (*Sedgwicki group*) corresponds generally with the foregoing in its vertical range. None of its species is known in the Lowest Birkhill; and only a single form lingers on into the Upper Gala period. The supposed Wenlock examples of this group occasionally quoted by palæontologists are probably fragmentary examples of the genus *Cyrtograptus*, Carr.

Of species of *Monograptus* worthy of notice in this place *M. priodon*, Bronn, is perhaps the most remarkable. If the Swedish palæontologists are correct in their reference of *M. Flemingii*, Salt., and *M. ludensis*, Murch., to this species, it is unequalled in its range, having existed from the close of the Birkhill period to the Middle of the Ludlow.

Monograptus tenuis, Portlock, and *M. gregarius*, Lapw., are the characteristic species of the Llandovery formation. *M. lobiferus*, M'Coy, distinguishes the upper half of the Llandovery formation; and *M. exiguus*, Nich., is peculiar to the lower division of the Tarannon. To this latter subformation also the remarkable species *M. turriculatus*, Barr., is generally restricted. *M. testis*, Barr., is apparently confined to a single zone in the Wenlock formation; and *M. Nilssoni*, Barr., and *M. scanicus*, Tullb., are strictly peculiar to the Lower Ludlow, not only in Britain, but also upon the continent of Europe.

Cyrtograptus, Carr.—Until very recently little was known of this very elegant and peculiar genus. Generally speaking, it is a very rare fossil in Britain, except along certain special horizons. Our oldest forms occur in the Upper Gala beds, where examples are few. In the Lower Wenlock they become more common, especially in the basal zones of *Cyrtograptus Murchisoni*, Carr., and *C. Linnarssoni*, Lapw. A single species has been recognized in the Lower Ludlow formation. In the Gala and Wenlock formations of Scania Dr. Tullberg has recently detected many new species belonging to this genus, which is there, as in Britain, peculiar to the strata *above* the Lower Gala. It is tolerably certain that similar forms await discovery in the corresponding rocks of Britain, and that this genus will eventually be found to characterize the strata above the middle line of the Gala group, as the genus *Rastrites* distinguishes those below it.

The most remarkable species hitherto detected in Britain is *Cyrtograptus Murchisoni*, Carr., which, as we have already shown, marks the basal beds of the Wenlock of Siluria, Scandinavia, and probably also of the less carefully studied areas in Central Europe.

Family ii. **Leptograptidæ.**

Like the previous family, that of the Leptograptidæ appears to have had but a very limited range in Palæozoic time. None of its species is known to occur in the Cambrian or Silurian. The family is exclusively Ordovician in its range, its oldest genera appearing in the Upper Arenig, and its newest forms vanishing within the limits of the Upper Caradoc.

As a whole, the family is especially characteristic of the Bala formation, numerous species pervading it from its base almost to its summit, while the individuals are distributed with tolerable equality throughout the entire succession.

The two sections into which the family is provisionally divided attain their maxima along widely separated horizons. The species composing the oldest section, which includes *Cœnograptus*, Hall, and its allies, culminate and disappear within the limits of the Llandeilo-Bala (Glenkiln) subformation. The species which compose the second section (which includes *Leptograptus*, *Amphigraptus*, &c.), on the other hand, are comparatively rare in the Llandeilo-Bala. They show a rapid increase in numbers and importance as we ascend into the Bala proper; and about the horizon of the Bala Limestone they become, in the Hartfell shales of the south of Scotland, most abundant and characteristic. Here, however, we suddenly lose sight of them; and not a fragment of a species of the Leptograptidæ has yet been detected in the higher zone of the Bala or in any more recent formation.

Cœnograptus.—The beautiful genus *Cœnograptus* of Hall, which we regard as the type of the older section of this family, is unknown outside the limits of the Llandeilo-Bala formation. Of the zone bounded below by the Llandeilo Limestone, and above by the deeper beds of the Caradoc proper, this genus is the peculiar and characteristic fossil. The form *Cœnograptus gracilis* of Hall marks these beds everywhere in Britain; and this fixes the systematic position of the *Cœnograptus*-bearing strata of Sweden, New York, and Australia. Along this zone the horizontal distribution of this form appears to have been world-wide.

Azygograptus.—By far the most remarkable genus at present assigned to this division is the strange form *Azygograptus* (Nich. & Lapw.). It may possibly be shown to belong to the Dichograptidæ. In that event the range of the Leptograptidæ would be confined to the Llandeilo and Bala periods, *Azygograptus* being the only genus of this family known in the Arenig formation.

Leptograptus &c.—Turning next to the second division of the family, we come to the type genus *Leptograptus*, one of the most puzzling of all the monoprionidian Graptolites. So frequently does it throw off extra simple or compound branches both from the arms and sicula, that there is some suspicion that the so-called genera *Pleurograptus*, *Amphigraptus*, &c., as defined by myself, are merely names for permanent varieties of this form. A few examples of *Leptograptus* have been met with in the Middle Llandeilo; but examples of this genus are not common till we pass above the line of the Bala Limestone, where, in the south of Scotland, they are found in extraordinary abundance.

The genera *Pleurograptus* and *Amphigraptus* are Upper Bala forms exclusively, occurring in association with *Leptograptus* in the Lower Hartfell shales in amazing profusion. The only species of this group deserving special mention here are *Leptograptus flaccidus*, Hall, and *Amphigraptus divergens*, Hall. The former is both a Glenkiln and a Hartfell fossil in Britain and America; the latter is restricted to the Middle Hartfell beds and the corresponding Lorraine shales of New York.

Family iii. **Dicranograptidæ.**

The family of the Dicranograptidæ, which is most intimately allied zoologically to that of the Leptograptidæ, is almost precisely coincident with that family in its vertical range, its oldest known forms occurring in the Upper Arenig, and its newest in the Upper Bala formation. Like the Leptograptidæ also its species are characteristic of the Bala formation. Few forms are found in the Lower Llandeilo or in the Upper Bala; but in the Llandeilo-Bala or Glenkiln zone they are, next to the Diplograptidæ, by far the commonest fossils. The family probably culminates here; but though there is a falling off in species there is no decrease in the number of individuals of Dicranograptidæ till we reach the Bala horizon of the limestone. Very few forms pass higher in the succession. A few forms are known both in Scotland and South Sweden, in the highest Bala zones, close to the line marking the base of the Silurian, but no Dicranograptidæ have hitherto been detected above that limit.

Dicellograptus.—Of the two genera which make up this family the genus *Dicellograptus*, Hopk., is the more prolific in species, and seems to have the more extended vertical and horizontal distribution. A form belonging to this genus has been met with deep within the Arenig formation; and its most recent species marks the highest known zone of the Bala rocks.

In the Llandeilo rocks of Wales forms of *Dicellograptus* are common; but the genus does not appear to attain its maximum until we reach the higher zones of the Glenkiln shales. In the succeeding Lower Hartfell beds examples occur in countless multitudes on several horizons, but the species are fewer. In the highest Birkhill only two species are known.

The most conspicuous species is *D. sextans*, Hall, which marks the Upper Llandeilo and Glenkiln shales in Wales and Scotland and their equivalents in Scandinavia and in North America. *D. complanatus*, Lapw., and *D. anceps* are the characteristic fossils of the Upper Hartfell beds, as *Dicellograptus Forchhammeri*, Geinitz, is of the Lower Hartfell.

Dicranograptus.—The genus *Dicranograptus* (which is, morphologically, merely a *Dicellograptus* whose branches are conjoined proximally for a portion of their length) is as yet unknown in the Upper Arenig. Its oldest known species is of Llandeilo age. It attains its specific maximum in the Glenkiln zones, only two British species surviving into the Lower Hartfell. In the Upper Caradoc subdivision the genus is as yet unknown.

The most conspicuous species is *D. ramosus*, Hall, an Upper Llandeilo and Glenkiln fossil in Britain. Like its associate *Cœnograptus gracilis*, Hall, its horizontal distribution appears to have been almost world-wide.

[To be continued.]

VI.—*On the Internal Structure of the Brain of* Limulus polyphemus. By A. S. Packard, Jun.

Several years ago I attempted to study the brain of the horse-shoe crab (*Limulus polyphemus*), and had it sliced into a large number of sections. Owing to interruptions these sections, made from unstained alcoholic specimens, were not examined. During the past winter I have been able, with the aid of Mr. N. N. Mason of Providence, to take up the study afresh. Mr. Mason has kindly made sections, both transverse and horizontal, stained with osmic acid,—also sections of the brain and supraœsophageal ganglion of the